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A stakeholder-based assessment framework applied to evaluate development scenarios for the spatial data infrastructure for Flanders

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ABSTRACT

Spatial Data Infrastructure (SDI) is the integration of a number of components to create a platform which enables a wide variety of stakeholders to access, share and use spatial data in an efficient and effective way. The way this platform should be set up and governed is a difficult decision, in which all these stakeholders have different views and objectives. In this paper, the Multi Actor Multi Criteria Analysis (MAMCA), developed by Macharis (2000, 2005), is discussed as a methodology for evaluating different development alternatives for SDI. The application of the methodology for the case in Flanders (Belgium) clearly shows its clear and visual interpretation strengths. This enables a thorough discussion of the possible implementation paths with their strengths and weaknesses by the stakeholders. The results show that the future of the SDI in Flanders could lie within the integration of the market in the SDI.

1. Introduction

Spatial data and the concept of Spatial Data Infrastructures (SDI) have gained importance during the last years. From a public policy point of view, spatial data offer many governmental possibilities to produce and use public information with different types of end users. The introduction of Geographic Information Systems (GIS) has made a significant contribution in terms of managing spatial data (Rajabifard, Feeney, Williamson, & Masser, 2003). But over the years, the need to exchange and share spatial data between different organizations has emerged (Crompvoets, Bregt, Rajabifard, & Williamson, 2004). This resulted in different initiatives that could be classified under the concept of a spatial data infrastructure. An SDI can be defined as the integration of a number of components to create a platform which enables a wide variety of stakeholders to access, share and use spatial data in an efficient and effective way (European Commission, 2007; Giff & Coleman, 2002; Kok & Van Loenen, 2005). There are many other ways to define an SDI (Chan, 2001; Grus, Crompvoets, & Bregt, 2007), but most definitions refer somehow to the SDI-components (e.g. data, technology, policies, standards and people (Crompvoets et al., 2004; Giff & Coleman, 2002; Rajabifard, Feeney, & Williamson, 2002)) and/or its purpose (European Commission, 2007; Vandenbroucke, Crompvoets, Vancauwenberghe, Dessers, & Van Orshoven, 2009).

In this paper, the Multi-Actor Multi-Criteria Analysis (MAMCA), developed by Macharis (2000, 2005) is discussed as a methodology to evaluate different development alternatives for SDI. The proposed methodological framework is applied for the SDI in Flanders (Belgium). Future scenarios with a time horizon of 2020, when the INSPIRE Directive (European Commission, 2007) should be fully implemented for each EU Member State, and the actions that should be taken in terms of the further development of the SDI are defined and assessed. These scenarios shape the context in which the SDI could develop in the future, taking into account the characteristics of the current set up of the SDI in Flanders and the demands of the stakeholders. The MAMCA methodology allows to elicitate the preferences of the (local) stakeholders and bases the evaluation of possible future scenarios on their objectives. The outcome is thus specific for the case in Flanders, but the methodology could be used in different settings or countries/regions.

Over the last years, there have been substantial investments in the development of SDIs. These investments, most of which are public funds, need to be justified towards the public. In other words, the SDI initiatives need to be assessed in order to obtain the necessary information on their impact and implications so that measures can be taken to improve the SDI in general (Crompvoets, Rajabifard, Van Loenen, & Delgado Fernández, 2008; Giff & Crompvoets, 2008).

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The assessment of SDIs appears to be complicated due to their dynamic, multi-faceted and constantly evolving nature, and the vaguely defined objectives (Crompvoets et al., 2008; De Man, 2006; Georgiadou, Rodriguez Pabón, & Lance, 2006; Grus et al., 2007; Nedović-Budić, Crompvoets, & Georgiadou, 2011). Many researchers have tried to assess SDIs (e.g. Crompvoets, 2006; Delgado Fernández, Lance, Buck, & Onsrud, 2005; Kok & Van Loenen, 2005; Masser, 1999; Onsrud, 1998; Vandenbroucke, Janssen, & Van Orshoven, 2008), but these attempts, however useful and valuable, either concentrate on one aspect of SDI, sector or stakeholder, are bounded by one region, or are still conceptual in nature.

When assessing SDIs, one has to take into account the fact that SDI development integrates issues from multiple disciplines, such as law, economics, geomatics and public administration science. SDIs were mainly introduced as a technical concept, but as SDI research evolved, so did the idea that it needs to be investigated by using a multiple as well as trans-disciplinary approach which acknowledges multiple realities (De Man, 2008).

In addition, stakeholders could have different motives or purposes to assess SDIs. According to Chelimsky (1997), there are three main purposes. The first purpose, accountability, looks at the cause and effects of a certain initiative as to where the second purpose, development, looks at the organisational implications. The third purpose includes knowledge evaluation. Furthermore, stakeholders might have different views on the objectives and benefits of SDIs, depending on their position and stake (De Man, 2006; Grus et al., 2007), which also need to be included.

One of the most important characteristics of the MAMCA is its ability to implement the preferences (criteria) of multiple stakeholders in an evaluating framework, enabling clear assessments per stakeholder. In complex decision making problems such as SDI, the input from different stakeholders with regard to their preferences and objectives is crucial for a successful further development. Through the objectives, the stakeholder specific criteria can be defined, which are then weighed by the stakeholders in order to determine their importance. Other relevant characteristics of MAMCA for further SDI development are its capability to take the multidisciplinary issues into account, and to deal with the level of complexity. On the basis of these methodological strengths, the MAMCA methodology was chosen to assess the future SDI development in Flanders.

The paper is constructed in the following way. In Section 2, the MAMCA methodology is briefly presented. Section 3 presents its application for the SDI development in Flanders. The paper ends with conclusions and a summary of the main application findings (Section 4).

2. Introducing a new assessment framework: the Multi-Actor Multi-Criteria Analysis (MAMCA)

The Multi-Actor Multi-Criteria Analysis (MAMCA) is an extension of the existing multi-criteria analysis (MCA) (Fandel & Spronk, 1985; Guitoni & Martel, 1998; Laarabi, Chevallier, & Martel, 1996). The MAMCA methodology allows researchers to evaluate different alternatives (policy measures, scenarios, technologies, etc.) with regards to the objectives of the different stakeholders that are involved in the decision making process. This methodology is unique in its field as it explicitly includes the stakeholders and uncovers their points of view. The methodology was developed by Macharis (2000, 2005, 2007) and has been used in many projects, mainly for transport related decision making problems (for an overview, see Macharis, De Witte, & Ampe, 2009).

The MAMCA consists of two phases (Macharis, 2005; Macharis et al., 2009). The first phase is mainly analytical and includes the gathering of all the necessary information. The second phase is the synthetic or exploitation phase and consists of the actual analysis. These two phases are divided into respectively four and three steps (Macharis et al., 2009), as can be seen in Fig. 1. The first step comprises of the problem definition and the determination of the possible alternatives for further development. In the second step, all relevant stakeholders are highlighted, together with their objectives. These objectives are then translated into criteria (step 3), which need to be weighed. In the fourth step, one or more measurable indicators are linked to each criterion. They allow evaluating each alternative with regards to a given criterion and are either quantitative or qualitative, depending on the criterion. The fifth step aggregates all the information from the previous steps into an evaluation matrix. The actual results are given in step six and are generated through multi-criteria analysis. This permits the analysis of the advantages and disadvantages of every alternative. The seventh and final step is the actual implementation of the results and is mainly directed towards the policy maker. More background information on the application of the MAMCA as a methodology in the context of SDIs can be found in Geudens, Macharis, Plastria, and Crompvoets (2009).

3. The case of spatial data infrastructure in Flanders

In this research, the investigated area is Flanders, the Dutch-speaking part of Belgium (Fig. 2). The objective is to determine the optimal strategy for the future development of SDI in the Flanders region.

The SDI in Flanders is mainly determined by the regulatory cooperation framework SDI-Flanders (Crompvoets et al., 2010). This cooperation framework is the successor of the GIS-Flanders which was founded in 1995 with the objective to optimize the production, use and exchange of spatial data. The participants of the GIS Flanders were responsible for the mutual acquisition, production, use and distribution of spatial data and for the introduction of training programs. These participants were the departments and organizations of the Flemish Government, the Flemish provinces and the Flemish municipalities. Moreover, all other public Flemish organizations are currently integrated into the SDI as a consequence of the adoption of the SDI Decree 2009 (AGIV. Organization: legal framework., 2011; Vlaamse Regering, 2011).

All organizations need spatial data and use them for different business processes, such as spatial planning, traffic accident registration or flood mapping. In other words, there is a significant number of organizations that produces, uses and shares spatial data. The main difficulty with the current SDI is the coordination and facilitation of the exchange of spatial data between these organizations (Vanden Broucke, Crompvoets, & Vancauwenberghe, 2011). Internal and external initiatives were introduced in order to improve the access, use and sharing of spatial data. It is therefore important to streamline these initiatives and to look for synergies. This will help to improve the performance of the SDI and will allow organizations to manage spatial data in an efficient and effective way.

Up to now, the SDI in Flanders has been mainly regulated by a hierarchical framework which stipulates the extent in which spatial data is produced and shared by different organizations. The INSPIRE Directive, which entails the development of a European spatial data infrastructure, was transposed into a Flemish decree in order to bind the different organizations in the SDI. The SDI Decree was adopted by the Flemish Government on February 20, 2009 (AGIV, 2011) and serves the commonly shared SDI-interest by organizing the SDI in such a way that it is efficient and effective in producing, exchanging, using and sharing spatial data. This decree also formed the legal basis for the shift of the cooperation framework GIS-Flanders into SDI-Flanders and is the starting-point for further development of the SDI in Flanders.

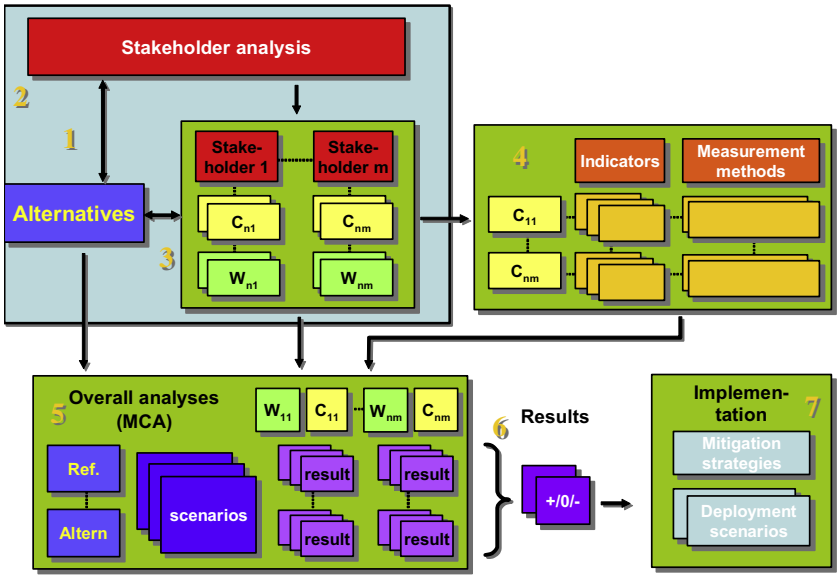

Fig. 1. The MAMCA methodology (*Source:* Macharis, 2005).

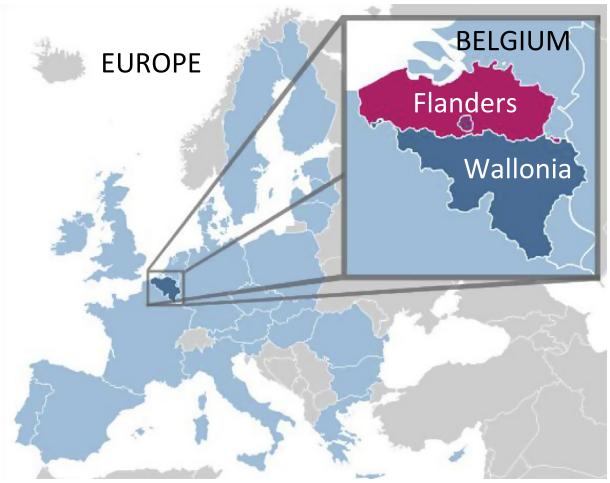

Fig. 2. Research area Flanders (*Source:* VIB).

3.1. Step 1: alternatives

A set of alternatives and scenarios for the further development of SDI has to be explored by focusing on the three main mechanisms of coordination that can be found in the public administration science literature: Hierarchy, Market and Network (Verhoest, Legrain, & Bouckaert, 2003). The key characteristics of these mechanisms of coordination, summarized in Table 1, are based on previous approaches to model the different coordination mechanisms (Kaufmann, Majone, & Ostrom, 1986; O' Toole, 1997; Peters, 2003; Thompson, Frances, Levacic, & Mitchell, 1991). The goal of these different mechanisms is to comprehend the coordination problems and the possible gains achieved through coordination. These six characteristics provide a structured overview of the most important implications of each coordination mechanism.

Hierarchies are based on authority for the interaction between different organizations and on the dominance and authority as the basic control system by using laws, regulations or rules. The Market as a coordination mechanism is based on competition, bargaining and exchange between actors. The price mechanism, incentives and the self-interest of actors 'coordinate' the activities of the different actors by creating an 'invisible hand'. Coordination within a Network takes the form of cooperation between actors whose inter-organizational relations are ruled by the acknowledgement of mutual interdependencies, trust and the responsibilities of each actor.

	Alternatives		
	Hierarchy	Market	Network
Basis of interaction	Authority and dominance	Exchange and competition	Cooperation and solidarity
Purpose	Consciously designed and controlled goals	Spontaneously created results	Consciously designed purposes or spontaneously created results
Guidance, control and evaluation	Top down norms and standards, routines, supervision, inspection, intervention	Supply and demand, price mechanism, self-interest, profit and losses as evaluation, courts, invisible hand	Shared values, common problem analyses, consensus, loyalty, reciprocity, trust, informal evaluation – reputation
Role of government	Top-down rule-maker and steering, dependent actors are controlled by rules	Creator and guardian of markets, purchaser of goods, actors are independent	Network enabler, network manager and network participant
Resources needed	Authority power	Bargaining information and power	Mutual cooperation trust
Theoretical basis	Weberian bureaucracy	Neo-institutional economics	Network theory

Table 1
The key characteristics of the 3 alternatives (Hierarchy, Market and Network).

	Hierarchy	Market	Network
Basis of interaction	Authority and dominance	Exchange and competition	Cooperation and solidarity
Purpose	Consciously designed and controlled goals	Spontaneously created results	Consciously designed purposes or spontaneously created results
Guidance, control and evaluation	Top down norms and standards, routines, supervision, inspection, intervention	Supply and demand, price mechanism, self-interest, profit and losses as evaluation, courts, invisible hand	Shared values, common problem analyses, consensus, loyalty, reciprocity, trust, informal evaluation – reputation
Role of government	Top–down rule-maker and steering, dependent actors are controlled by rules	Creator and guardian of markets, purchaser of goods, actors are independent	Network enabler, network manager and network participant
Resources needed	Authority Power	Bargaining Information and Power	Mutual Cooperation Trust
Theoretical basis	Weberian bureaucracy	Neo-institutional economics	Network theory

For this analysis, five different alternatives (scenarios) were determined for the further development of the SDI in Flanders in 2020. The first alternative (going concern) is an evolution of the SDI in Flanders within the current legal framework, assuming only the implementation of the INSPIRE rules. This alternative can be considered as the reference SDI-development scenario to which other alternatives can be compared. The second alternative is an increase of the hierarchical framework by including additional types of spatial data and/or actors in laws, regulations or rules. The third alternative implies a status quo of the hierarchy and a tendency towards a market approach. The fourth alternative implies a decrease of hierarchy and an increase of cooperation networks with a legal framework built down ensuring only the production, use and exchange of core spatial datasets. The fifth alternative is comparable to the fourth one, but the hierarchy is phased out for the benefit of a market approach.

These alternatives were generated based on a detailed literature review and expert meetings with several prominent scholars in the research field of SDI (in Flanders). Starting from the assumption that the current SDI in Flanders is a combination of the three previously mentioned, coordination mechanisms with several degrees of freedom in which the SDI may evolve in the future. In one of the organized workshops, we showed the stakeholders a first set of alternatives and thanks to their critical feedback a final set was taken as the basis for the further evaluation.

The future development strategies are evaluated with regard to the criteria of the different stakeholders in the context of the further SDI development in Flanders. Table 2 summarizes these scenarios according to the following characteristics: context, role of the government, role of the private sector and required government funding. These four characteristics describe the scenarios and provide a structured overview of the five alternatives.

The first characteristic (context) describes the development of the SDI with regard to the current hierarchical framework. This framework is clearly defined and can increase or decrease according to the future development of the SDI. Based on the three coordination mechanisms that were introduced earlier, five combinations were made for the SDI in Flanders. Note that the foundation of each scenario is the network, since this coordination mechanism forms the foundation of the SDI together with the legal framework. The second characteristic is the governmental role. According to which strategy the government will follow, it will likely have to play a different role in order to ensure the success of the SDI. The third characteristic is the role of the private sector. Up to now, the integration of the private sector in the SDI is rather limited since the SDI's initial focus was primarily on public spatial data. However, integration of market players, both on the demand and supply side, could have a significant impact on how the SDI will be organized. The fourth characteristic is the required government funding. As this analysis focuses on future development strategies, it is challenging to forecast the level of funding. However, it is relevant to have an indication (low, medium and high). This last characteristic provides the decision maker with a rough indication on the financial implications of each scenario.

3.2. Step 2: stakeholders

In the MAMCA, it is essential to determine the relevant stakeholders, in order to incorporate their views in the study. It boosts the acceptance rate of the initiative when the eventual decision has to be made. In this paper, a stakeholder is defined as a person or a group of individuals that is able to influence the objectives of an organization or that can be influenced themselves (Freeman, 1984).

	Alternatives				
	Going concern	Increasing hierarchy	Hierarchy/Market	Decreasing hierarchy and increasing network	Decreasing hierarchy and increasing market
Context	Development according to the current hierarchical framework	Increasing the legal basis of the SDI by integrating new types of data and services	Current Hierarchy with Market-based approach for non-core activities	Overregulated Hierarchical framework is built down and complemented by Network-based approach	Overregulated Hierarchical framework is built down and complemented by Market-based approach
Role of the government	Top–down rule maker and responsible for funding	Top–down rule maker and responsible for funding	Market controller and participant	Rule maker and network enabler	Rule maker and market partner
Role of the private sector	Participant with limited market power	Participant with limited market power	Participant with high market power	Participant with higher market power	Participant with high market power
Required government funding	Medium	High	Medium	Low	Low

Table 2
Summary of the 5 scenarios for the MAMCA.

	Going Concern	Increasing Hierarchy	Hierarchy/Market	Decreasing Hierarchy and increasing Network	Decreasing Hierarchy and increasing Market
Context	Development according to the current hierarchical framework	Increasing the legal basis of the SDI by integrating new types of data and services	Current Hierarchy with Market-based approach for non-core activities	Overregulated Hierarchical framework is built down and complemented by Network-based approach	Overregulated Hierarchical framework is built down and complemented by Market-based approach
Role of the government	Top–down rule maker and responsible for funding	Top–down rule maker and responsible for funding	Market controller and participant	Rule maker and network enabler	Rule maker and market partner
Role of the private sector	Participant with limited market power	Participant with limited market power	Participant with high market power	Participant with higher market power	Participant with high market power
Required government funding	Medium	High	Medium	Low	Low

Four main stakeholder groups were defined. The first stakeholder group includes the Flemish Government. It is divided into two levels: local (municipalities) and regional/federal (provinces, Flemish public organizations and several organizations operating at federal level). The private sector is the second stakeholder group and is only investigated from a user point of view (so not the private sector as a producer/provider of data and services). The third stakeholder group is the utility sector, that uses and produces a significant amount of spatial data. The fourth stakeholder group is the research and development (R&D) sector, consisting of educational and research organizations. These organizations have a substantial need for spatial data in order to perform their education and/or research.

Determining these stakeholders was an ongoing process with multiple reviews and adaptations due to frequent contacts with the stakeholders themselves and meetings with experts in the field of SDI and geographic information. They were determined on the basis of their relevance, commonly shared objectives and demand regarding the further development of the SDI. It is important to highlight that the private sector is not well embedded in the current SDI as companies are not represented in the cooperation framework SDI-Flanders. However, all four determined stakeholder groups have an interest with regard to the SDI in Flanders and are looking to get even more involved.

3.3. Step 3: criteria and weights

The third step of the MAMCA includes the determination of the criteria for each stakeholder and the assignment of the criteria weights. Different strategies are valid when determining these criteria. In this study, a combination of different techniques was used to determine a specific set of criteria per stakeholder as well as their respective weights. The starting point was the organization of several visits to key players of each stakeholder group. They were asked to suggest their key criteria for the future development of SDI in Flanders. Next, a literature study was performed to further determine and justify the specific set of criteria. The resulting preliminary list was set up and validated by a number of key players in the SDI in Flanders, such as the National Geographic Institute, the Agency for Geographic Information Flanders, AGORIA (association representing the private companies and utilities), the Department Services for General Public Policy of the Flemish government, and the Association of Flemish cities and municipalities.

The feedback from the different organizations resulted into a final set of criteria per stakeholder which resulted in a criteria tree (Fig. 3). This criteria tree represents the objectives of the key stakeholders for the further development of SDI in Flanders.

The two levels of the government have similar objectives, but different priorities. For both groups, the following criteria were determined: the importance of easily accessing spatial data and the availability of the datasets needed (access and availability), up-to-date data (actual data), the importance of stable and adequate funding policies to pursue the stated objectives for the future (funding), the price to purchase the basic data (price of basic data), the need for clear protocols for storing spatial data (clear storage agreements), cost efficiency, data accuracy and clear archiving agreements.

The R&D sector has three main criteria (data, metadata and services) that are divided into several sub-criteria. The data criterion was further divided into the following sub-criteria: existence of spatial data, standardization and the allowance of the user to process spatial data at multiple levels (multiple processing levels). The metadata criterion was subdivided into metadata quality, metadata completeness and standardization. Finally, the services criterion was classified into access and distribution services. Class access services was subdivided into sub-criteria flexibility of the access format, price, user access restrictions and access performance. Class distribution services was subdivided into sub-criteria valorization and network efficiency.

The criteria determined for the utility sector are access and availability, up-to-date (actual data), cost efficiency, data accuracy and clear (governmental) contracts.

The private sector values the access and availability, up-to-date data (actual data), standardized agreements, price of basic data, data accuracy and liability. This last criterion is important when private organizations acquire spatial data from the public sector that are processed in order to add value to these spatial data resources. The private organization could therefore be made accountable for these value added data which might have important implications.

The allocation of the weights was the final phase of the third step in the MAMCA methodology. These weights (between 0 and 1) were assigned by different members of each stakeholder group by using the Analytical Hierarchy Process (AHP) method (Saaty, 1980; 1988). This multi-criteria analysis technique uses pairwise comparisons to generate a ranking of the different criteria. Each criterion was evaluated with regard to the others by using a 1–9 comparison scale.

At least five members of each stakeholder group were contacted and had to evaluate their set of criteria with regard to the overall objective, being the successful development of the SDI in Flanders. Based on the 9 point scale, the AHP method uses the mathematical techniques of eigenvectors and eigenvalues to determine the weight of each criterion (Saaty, 1980; 1988).

Table 3 provides an overview of the weight allocations of the criteria per stakeholder group. These weights were determined by taking the mean of the individual weights for each respondent per stakeholder group. Note that for the R&D stakeholder group, only the weights are given for the main criteria.

Stakeholder group and criteria	Weights
Regional/federal government	
Actual data	0.177
Access and availability	0.165
Funding	0.157
Data accuracy	0.128
Clear storage agreements	0.120
Cost efficiency	0.098
Price of basic data	0.084
Clear archiving procedures	0.071
Local government	
Actual data	0.273
Clear storage agreements	0.169
Access and availability	0.167
Funding	0.128
Data accuracy	0.103
Cost efficiency	0.073
Price of basic data	0.070
Clear archiving procedures	0.025
R&D sector	
Metadata	0.485
Data	0.317
Services	0.198
Utility sector	
Actual data	0.262
Data accuracy	0.254
Access and availability	0.243
Cost efficiency	0.176
Clear governmental agreements	0.066
Private sector	
Access and availability	0.308
Data accuracy	0.230
Actual data	0.169
Price of basic data	0.141
Standardized agreements	0.078
Liability	0.073

Table 3 shows that the most important criterion for both the regional/federal and local government is 'actual data' with respective weights of 17.7% and 27.3%. Note that 'access and availability' can also be considered as very important for both governmental levels. This criterion refers to the need for spatial data to be accessed easily and exchanged rapidly without any bottlenecks. This links to one of the key objectives of the SDI in Flanders (Vlaamse Regering, 2011). For the local government, the second most important criterion is the need for 'clear storage agreements' with a weight of 16.9%. This can be explained due to the fact that the local level is a very important player in the SDI concerning the storage and production of key spatial datasets.

For the R&D sector, 'metadata' is the most important criterion with a weight of 48.5%. This can be explained by the fact that this aspect is very important for the R&D sector as users who would like to be well-informed if the spatial data fits their demands. Their ability to perform relevant and state of the art research depends on the ability to acquire the right spatial data needed for the research. If the spatial datasets are well documented with clear and correct metadata, the spatial data searching could be enhanced.

The ranking for the utility sector shows a focus on the 'access and availability' of spatial data (26.2%) and the two quality aspects of the data being 'data accuracy' and 'access and availability' with respectively 25.4% and 24.3%. Another remarkable result is that this stakeholder is not very interested in clear contracts that are agreed with the government.

For the private sector, the same three criteria as for the utility sector top the list, be it in a different order and with different weights. The private sector puts the most interest in the 'access and availability' of spatial data (30.8%), followed by 'data accuracy' (23.0%) and 'actual data' (16.9%). This stakeholder is not very interested in 'standardized contracts' which could suggest that this stakeholder prefers to access and use public spatial data on an *ad hoc* basis.

3.4. Step 4 and 5: indicators and analysis

In the fourth step of the MAMCA, the stakeholder criteria are "operationalized" by appointing indicators that help the analyst in measuring the performance of each alternative with regard to the single criterion. For example, the indicator for the criterion 'actual data' is the 'frequency of updates'. Hence, an assessment for the up-to-datedness can be made for each of the alternatives. In appendix A, the list of indicators for each criterion is listed. The measurement methods related to the indicators are all qualitative in nature as the considered alternatives are future situations that have not been studied yet. This approach was strongly supported by key expert consultation combined with a literature study to argument the pairwise comparisons made in the final step. Similar to the weight contribution in step 3, the AHP method was used to obtain the final ranking. These pairwise comparisons were made in a pairwise matrix by using the 1–9 scale by Saaty (1980, (1988) (see Table 4 for an example). The scores of the 1–9 scale needed to be filled in for the top right part of the matrix above the main diagonal only. For each criterion C_i, the pairwise matrix needed to be completed by evaluating the different alternatives A_j.

3.5. Step 6 and 7: results and implementation

On the basis of the weights of the criteria obtained in step 2 and the pairwise comparisons of step 5, a score was calculated for each scenario and stakeholder group. The following figures show the results for each stakeholder.

First, Fig. 4 illustrates the results for the regional/federal governments. The horizontal axis shows the different criteria listed together with their weights (represented by the rectangles above each criterion) which are defined according to the values on the left vertical axis (Obj%). The right vertical axis measures the performance of each alternative with regard to each single criterion and the overall performance situated on the right of the figure (Alt%). The figure shows two alternatives that are most preferred by the regional/federal governments. The Hierarchy/Market alternative is preferred due to its high performance on two finance-related criteria: the price of basic data and the funding. The Increasing Hierarchy is preferred due to a high performance on the archiving and storing agreements and the access and availability. The Decreasing Hierarchy/Increasing Market alternative is the third most optimal alternative, mainly due to its performance on the cost efficiency and actual data. The Going Concern and the Decreasing Hierarchy/Increasing Network do not stand out in any one of the criteria, hence their respective fourth and fifth place in the ranking. The results for the local government are very similar to the one of the regional/federal government except that the Going Concern is the least preferred alternative. A sensitivity analysis, exploring

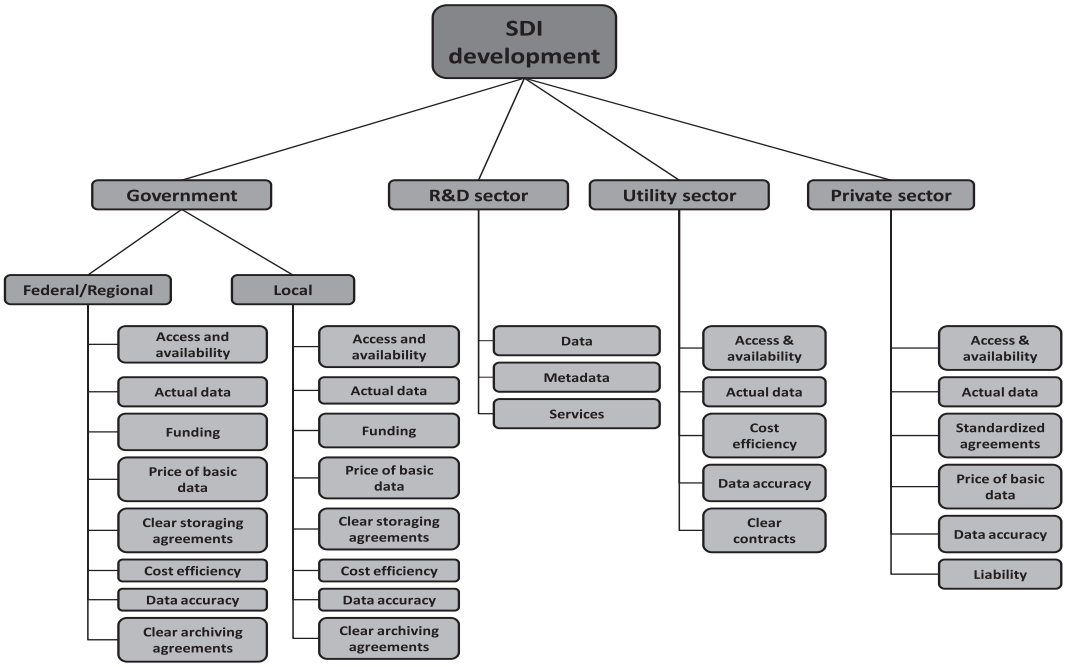

Fig. 3. Criteria tree for the SDI development in Flanders.

Table 3
Criteria and weight allocation.

Criteria	Ranking regional/Federal government
Actual data	0.177
Access and availability	0.165
Funding	0.157
Data accuracy	0.128
Clear storage agreements	0.120
Cost efficiency	0.098
Price of basic data	0.084
Clear archiving procedures	0.071
	Ranking Local Government
Actual data	0.273
Clear storage agreements	0.169
Access and availability	0.167
Funding	0.128
Data accuracy	0.103
Cost efficiency	0.073
Price of basic data	0.070
Clear archiving procedures	0.025
	Ranking R&D sector
Metadata	0.485
Data	0.317
Services	0.198
	Ranking utility sector
Actual data	0.262
Data accuracy	0.254
Access and availability	0.243
Cost efficiency	0.176
Clear governmental agreements	0.066
	Ranking private sector
Access and availability	0.308
Data accuracy	0.230
Actual data	0.169
Price of basic data	0.141
Standardized agreements	0.078
Liability	0.073

the effects of a change of the weights on the ranking, can be performed.

Table 4
Pairwise matrix.

C_i	A_1	...	A_j	...	A_n
A_1	1				
...		1			
A_j			1		
...				1	
A_n					1

The results for the private sector are shown in Fig. 5. The Decreasing Hierarchy/Increasing Market alternative is most preferred as it strengthens the position of the private sector in the SDI. According to the associated scores, the private players will have better access to up-to-date spatial data. The increasing Hierarchy comes in second due to its score on the pricing policy and the standardized agreements. As mentioned earlier, the private sector is only considered from a user perspective. An Increased Hierarchy could lead to more clarity about the conditions for using the public data. The Hierarchy/Market alternative performs well on data accuracy but performs less on all other criteria. The alternatives Going Concern and Decreasing Hierarchy/Increasing Network are again the least preferred ones.

Fig. 6 shows the general results for the R&D sector. This stakeholder group defined three main criteria which were divided into several sub-criteria. From this figure, it is clear that the Increasing Hierarchy is the most preferred alternative, followed by the Hierarchy/Market alternative. The high performance of the Increasing Hierarchy is due to its performance on the metadata criterion. This criterion was also stated as most important by the R&D sector since adequate and correct metadata improves the access to different types of spatial data needed for scientific research. The results of the other four alternatives are relatively similar to each other, except for the low performance on the metadata criterion for the Decreasing Hierarchy/Increasing Market alternative.

For the utility sector, the analysis provided the following results (Fig. 7). The most preferred alternative is the Decreasing Hierarchy/Increasing Market since it allows this stakeholder to access up-to-date data and to set up clear contracts. The

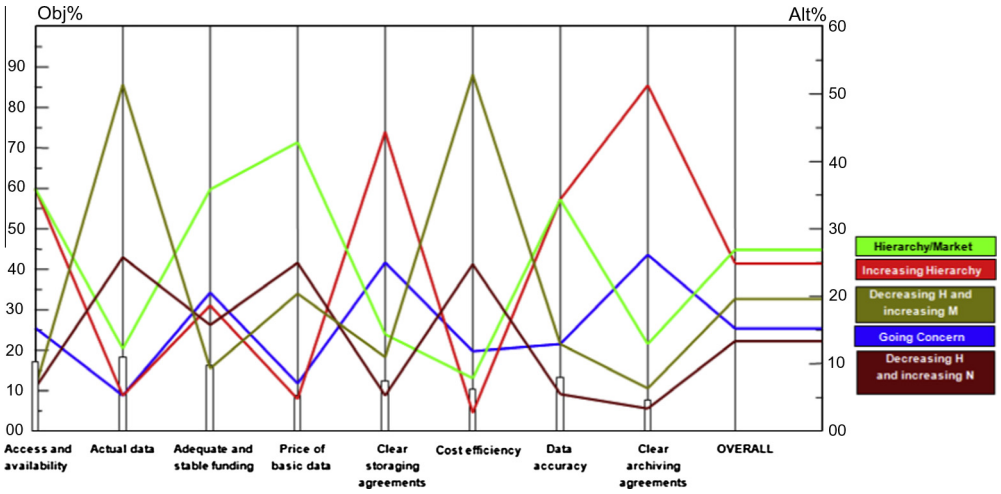

Fig. 4. Results for the regional/federal governments.

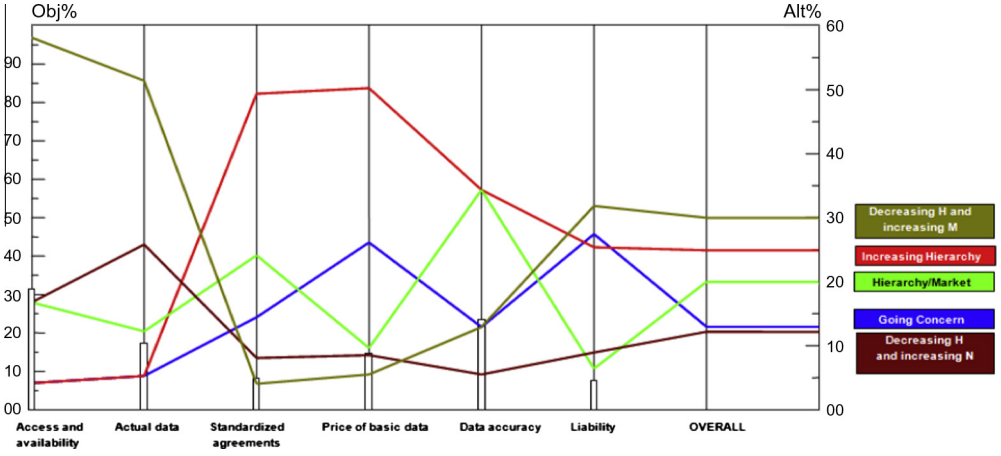

Fig. 5. Results for the private sector.

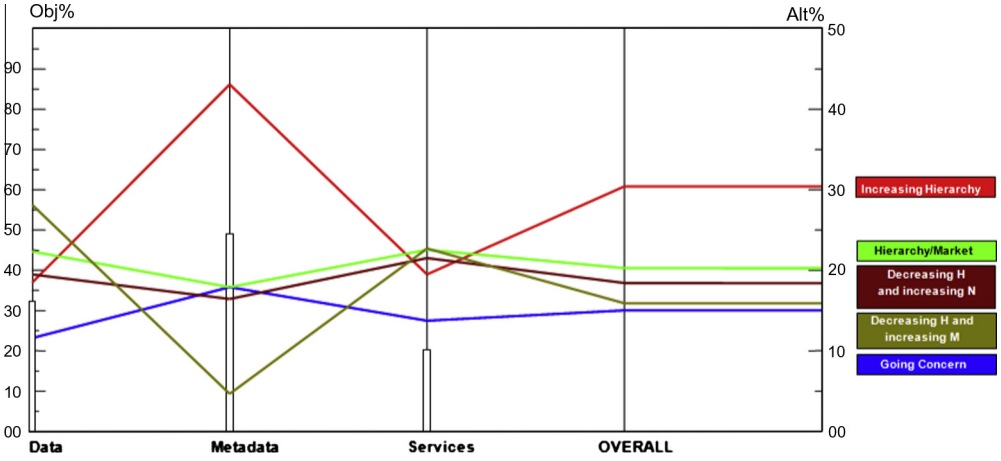

Fig. 6. Results for the R&D sector – general results.

Hierarchy/Market alternative performs well on data accuracy and performs average for all other criteria. The Increasing Hierarchy performs well on cost efficiency under the assumption that the trade-off between revenues and costs is easier in a non-competitive environment. The other two alternatives, the Decreasing Hierarchy/Increasing Network and the Going Concern appear to be less interesting for this stakeholder.

Next, it can be interesting to summarize the results for the four stakeholder groups together. The Increasing Hierarchy alternative can be found in the top 3 for every stakeholder group, but it only

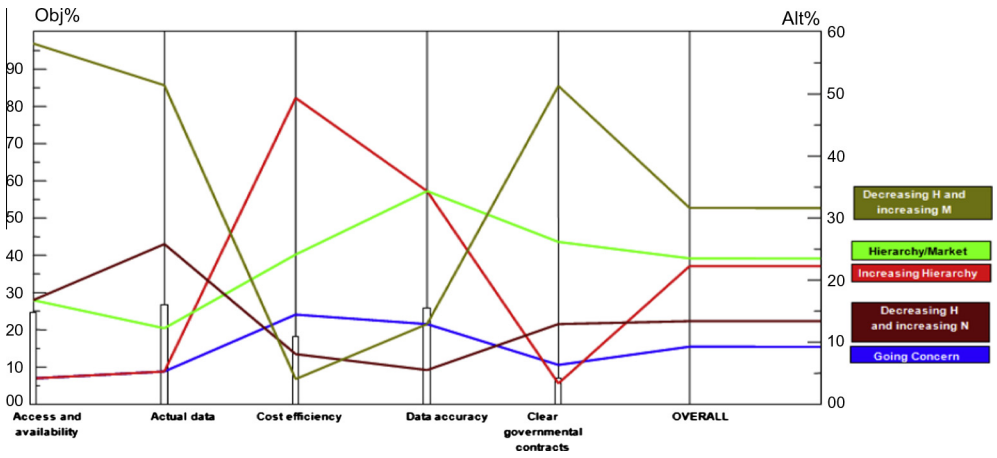

Fig. 7. Results for the utility sector.

tops the list once (for the R&D sector). Both the private and utility sectors prefer the Decreasing Hierarchy/Increasing Market alternative since this alternative likely provides them with more liberty to operate within the SDI and to strengthen their position as a key SDI stakeholder. The Hierarchy/Market alternative is most preferred by the government. This result could be expected since this alternative reflects the current legal framework and does not decrease the power of the public sector within the SDI. It only allows the Market to integrate in the SDI by creating an environment wherein both the public and private sectors operate. The alternatives Decreasing Hierarchy/Increasing Network and Going Concern are the least preferred alternatives for the further development of the SDI in Flanders.

This summary indicates that a further integration of these stakeholders is needed for the development of the SDI. Up to now, the SDI in Flanders is strongly public-oriented with limited market integration. The results of the MAMCA argue that the next step in the SDI development for Flanders could be the integration of private players as well as utility companies, and therefore creating mutually beneficial relations. How this integration should take place is still uncertain. The results of the MAMCA however provide a solid and structured basis for further discussion. Based on the results and implications from these results, the debate on the SDI development in Flanders can be further stimulated since SDI and SDI assessments are dynamic processes with complex interactions. With these MAMCA-results, the decision makers should be able to choose for the best option for the future development of SDI in Flanders, taking into account the different points of views of the stakeholders.

Finally, the main outcomes of the MAMCA application have been presented at the General Assembly on the Management of Geographical Information in Flanders (Staten-Generaal Vlaanderen Geoland, December 2011). The participants of this annual event were mainly important decision makers and policy makers of the governments in Flanders (at local, provincial, regional and federal levels). Moreover, the outcomes were also presented and discussed at the Council of the cooperation framework GDI-Flanders. This is the main coordination body of the SDI in Flanders and consists of representatives of the main stakeholders. The presentations of the MAMCA results served as an important motive for the debate on the further development of SDI in Flanders.

4. Conclusion

This paper introduces the MAMCA as an evaluation method for different SDI development paths. Its strengths for SDI development assessment include a clear and visual interpretation, its capability to clearly present the different stakeholders views together with their underlying reasons, the view on SDI as a multi-disciplinary concept, the capability to deal with the SDI complexity, and the evaluation of several alternatives using the stakeholder's specific multiple criteria.

The paper presented the application of the MAMCA as a methodology for the development of SDI in Flanders. The current SDI in Flanders is determined by the SDI decree and exists mainly of public organizations which can be considered as a network of cooperating public organizations producing, exchanging, using and sharing spatial data. For the definition of possible development alternatives, the Hierarchy – Market – Network approach was applied as a framework for public coordination, as governance might be considered as the main difficulty for SDI in Flanders. Five alternatives were proposed for the evaluation as well as four stakeholder groups; governments, the research & development sector, the private sector and the utility sector. For each stakeholder group, different criteria were defined and evaluated through the assignment of weights. The weight allocation was performed through the AHP technique, which uses pairwise comparisons on a 1–9 scale. This is a crucial step in the MAMCA, as it represents the explicit opinion of the different stakeholders. The results of this weight allocation showed preference differences with regards to the further development of the SDI in Flanders. Nonetheless, certain criteria were relevant for most stakeholders.

The results showed that the future of SDI in Flanders could lie within the integration of the market in the SDI. The integration of private and utility players in SDI could provide new benefits to SDI as a whole, since it could stimulate innovation and differentiation. However, it remains important to maintain the hierarchical framework as set by the INSPIRE Directive and the Flemish SDI decree. The results also show that the development of SDI in Flanders is more than just implementing the INSPIRE directive. This is shown by the low scores for the Going Concern alternative. Moreover, an increased effort to strengthen the cooperation among stakeholders is not preferred.

Another important finding of the analysis is that each alternative has its drawbacks. In many cases, the results show trade-offs between the different criteria, indicating a difficult compatibility. In order to tackle these issues, a consensus needs to be reached between the different stakeholders.

Finally, the results of the MAMCA application allow looking for a combination of the different alternatives, reaching to a scenario that might satisfy every stakeholder according to their objectives. This way, the results could support policy makers to discuss the further development of SDI.

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Appendix A

Table. Criteria, indicators and measurement methods.

Criteria	Indicator
Regional/Federal government	
Access and availability	Efficiency of access
Actual data	Frequency of updates
Funding	Degree of public funding
Price of basic data	Price level of basic data
Clear storage agreements	Updating speed
Cost efficiency	Efficiency improvement
Data accuracy	Data accuracy level
Clear archiving procedures	Degree of archiving
Local government	
Access and availability	Efficiency of access
Actual data	Frequency of updates
Funding	Degree of public funding
Price of basic data	Price level of basic data
Clear storaging agreements	Updating speed
Cost efficiency	Efficiency improvement
Data accuracy	Data accuracy level
Clear archiving procedures	Degree of archiving
Research and Development (R&D) Sector	
Data – Existence	Availability of datasets
Data – Standardization	Degree of standardization
Data – Multiple processing levels	Efficiency to process data
Metadata – Quality	Degree of metadata quality
Metadata – Completeness	Degree of metadata completeness
Metadata – Standardization	Degree of standardization
Services – Access – Flexibility Access format	Flexibility of access formats
Services – Access – Price	Price level to access basic data
Services – Access – User restrictions	Extent to which conditions do not restrict the use of spatial data
Services – Access – Access performance	Time needed to access to data
Services – Distribution – Valorisation	Degree of valorisation
Services – Distribution – Network efficiency	Efficiency of the network service
Utility sector	
Access and availability	Efficiency of access
Actual data	Frequency of updates
Cost efficiency	Efficiency improvement
Data accuracy	Data accuracy level
Clear governmental agreements	Ability to specify the terms and conditions of contracts
Private sector	
Access and availability	Efficiency of access
Actual data	Frequency of updates
Standardized agreements	Use of identical agreements for multiple datasets
Price of basic data	Price level of basic data
Data accuracy	Data accuracy level
Liability	Extent to which the private sector can incur liability by using public sector datasets

Stakeholder group and criteria	Indicator
Regional/Federal Government	
Access and availability	Efficiency of access
Actual data	Frequency of updates
Funding	Degree of public funding
Price of basic data	Price level of basic data
Clear storage agreements	Updating speed
Cost efficiency	Efficiency improvement
Data accuracy	Data accuracy level
Clear archiving procedures	Degree of archiving
Local government	
Access and availability	Efficiency of access
Actual data	Frequency of updates
Funding	Degree of public funding
Price of basic data	Price level of basic data
Clear storaging agreements	Updating speed
Cost efficiency	Efficiency improvement
Data accuracy	Data accuracy level
Clear archiving procedures	Degree of archiving
R&D sector	
Data – Existence	Availability of datasets
Data – Standardization	Degree of standardization
Data – Multiple processing levels	Efficiency to process data
Metadata – Quality	Degree of metadata quality
Metadata – Completeness	Degree of metadata completeness
Metadata – Standardization	Degree of standardization
Services – Access – Flexibility Access format	Flexibility of access formats
Services – Access – Price	Price level to access basic data
Services – Access – User restrictions	Extent to which conditions do not restrict the use of spatial data
Services – Access – Access performance	Time needed to access to data
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Services – Distribution – Network efficiency	Efficiency of the network service
Utility sector	
Access and availability	Efficiency of access
Actual data	Frequency of updates
Cost efficiency	Efficiency improvement
Data accuracy	Data accuracy level
Clear governmental agreements	Ability to specify the terms and conditions of contracts
Private sector	
Access and availability	Efficiency of access
Actual data	Frequency of updates
Standardized agreements	Use of identical agreements for multiple datasets
Price of basic data	Price level of basic data
Data accuracy	Data accuracy level
Liability	Extent to which the private sector can incur liability by using public sector datasets

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